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CARLETON

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RSPA-00-8309-1

Associate Administrator for Hazardous Materials Safety
US Department of Transportation
Washington DC 20590-0001
Attention: Exemption Branch

October 6, 2000

Subject: Application for Exemption to a Portion of Regulation 178.65, Specification 39 "Non-Reusable (Non-Refillable) Cylinders"

Gentlemen:

Carleton Technologies Incorporated, a manufacturer of pneumatic control components and systems, wishes to file for a special exemption as allowed by the Code of Federal Regulation Title 49, Part 107, Subpart B, paragraph 107.103. The portion of the regulation which we require relief is specification 39, "Non-Reusable (Non-Refillable) Cylinders", paragraph 178.65.

Under the Department of Transportation Exemption No. DOT-E 7765 Carleton has previously shipped over 17,000 high pressure gas bottles to Martin Marietta and Rockwell International, Missile Systems Division. These gas bottles were shipped without incident. Carleton has shipped over three hundred and fifty (350) gas cylinders under DOT-E 8865 without incident. In addition, Carleton has shipped over 27,000 gas bottles to Texas Instruments, Sherman Texas, and various branches of the United States military against these and other D.O.T. exemptions and Certificates of Equivalency without incident.

The latest request is required in order to ship our gas bottle system to Lockheed Martin, Orlando Florida. Our gas bottle is to be integrated into Lockheed Martin's JASSM missile development program.

GAS BOTTLE DESCRIPTION

The assembly we propose to ship consist of two (2) pyrotechnic cutters (DOT class 1.4s) on two (2) hermetically sealed high pressure gas cylinders. Each cylinder contains Helium gas. One cylinder is pressurized to 9200 PSIG ±200 PSIG in a 16 cubic inch volume, and the other cylinder is pressurized to 10,700 PSIG ±200 PSIG in a 25 cubic inch volume. The gas cylinders consist of cylindrical/spherical halves fabricated from PH13-8Mo stainless steel. (PH13-8Mo is a high temperature, corrosion resistant, precipitation-hardening, martensitic stainless steel.) The halves are welded together per MIL-STD-2219. The pyrotechnic cutter is used to initiate gas release through an exit port. Safety release burst disks are designed into each cylinder.

The configuration of each gas bottle manufactured shall conform to Carleton Technologies Inc drawing B43547. A copy of the drawing is enclosed as Attachment A.

The pressurized Helium is classified as a Division 2.2, non-flammable compressed gas.

The gas bottle will be fabricated, inspected and tested per the manufacturing flow chart in Attachment B.

A qualification Program for this gas bottle will include the following environmental tests: Temperature Shock, High and Low Temperature Exposure, Humidity, Salt Fog, Mechanical Shock, Vibration, Burst Pressure. A copy of the Qualification Procedure would be available upon request.

The engineering calculations, per DOT regulations 178.65 (d) (1), used in determining the wall stresses at service pressure, test pressure, and burst pressure are shown in Attachment C.

Carleton wishes to submit for exemption on the following paragraphs:

178.65 (b) Material

(1) "Steel. (i) The steel analysis must conform to the following:"

Revise to:
"The cylinders will be made from heat treatable 13-8Mo"

178.65 (b)

(4)"Welding procedures and operators must be qualified in accordance with CGA Pamphlet C-3"

Revise to:
"Welding procedures and operators must be qualified in accordance with CGA Pamphlet C-3 or Mil-STD-2219"

178.65 (f)

(2)"One cylinder taken from the beginning of each lot, and one from each 1,000 or less successivley thereafter, must be hydrostatically tested to destruction. The entire lot must be rejected"

Revise to:

"One cylinder taken from the beginning of each lot must be hydrostatically tested to destruction. The cylinder may be a complete assembly or a complete assembly with a simulated housing and mating cylinder. The entire lot must be rejected"

Reason:

The lot of cylinders will consist of less than 500 units. Hydrostatically testing one for burst testing will result in the testing of more units and is considered a more aggressive test plan. The cost of the non-pressure bearing components is extremely high. The option to destructively test a unit with a simulated housing and mating cylinder is to reduce the amount of hardware destroyed while maintaining the pressure boundary integrity completely.

178.65 (f)

(3) "A "lot" is defined as the quantity of cylinders successively produced per production shift (not exceeding 10 hours) having identical size, design, construction, material, heat treatment, finish and quality."

Revise to:

' A lot is defined as the quantity of pressure vessels fabricated from the same material, manufactured by the same process and heat treated in the same equipment under the same conditions of time, temperature, and atmosphere and may not exceed a quantity of 500."

> Carleton will collect hardness data on samples from each heat cycle of material to monitor process stability and consistency. Carleton has used this procedure in the past to monitor material and believes it to be an acceptable means to attest to a controlled and stable heat treat process. This data would be available upon request.

178.65 (f) "Flattening Tests"
"One cylinder must be taken from the beginning of..."

Revise to: "A sample ring must accompany each lot. The sample ring will be from the same material lot as the bottles themselves are made."

(1) "The flattening test must be made on a cylinder...."

Revise to: "A sample ring must accompany each lot."

(2)"A ring taken from a cylinder may be flattened...."

Revise to: "A ring representative of a cylinder may be flattened...."

Due to the very high costs of the cylinder, sectioning a completed cylinder to produce test rings for flattening, would not be a cost effective method to comply with this requirement. Carleton proposes, manufacturing the test rings out of the same bar stock the cylinder halves are machined out of. These manufactured test rings would duplicate the cylinder in every dimension, thus providing a considerably less expensive sample for testing.

(3) **Add:**
Flattening between flat plates is authorized.

(4)"Cylinders and test rings must not crack when flattened so that their outer surfaces are not more than six times wall thickness apart when made of steel."

Revise to:
"Test rings must not crack when flattened so that their outer surfaces are not more than (15) times wall thickness apart when made of steel."

(5) "If any cylinder or ring cracks when subjected to the specified...."

Revise to: "If any ring cracks when subjected to the specified flattening test, the lot of cylinders represented by the test must be rejected."

The proposed mode of transportation for shipping is motor vehicle, railfreight, and cargo aircraft only. With the approval of the exemption, there will be no increase in risk during transport through any of the above means. In fact, the gas bottle will be designed such that the safety requirements of this DOT specification are met or exceeded.

The proposed schedule of events is as follows to meet the highly aggressive development program of Lockheed Martin's JASSM program:

15 October 2000	-Build 2 development units •Development units built per attachment B flow chart
20 October 2000 -	Development Testing Complete •Testing included burst and proof pressure tests
9 March 2001 -	Assembly of 6 units for qualification complete •Units built per manufacturing, inspection and test flow chart in attachment B
9 March 2001 -	Ship 6 tactical units to Lockheed Martin
28 May 2001 -	Qualification complete

Carleton is confident, based on prior experience and development testing, that the level of safety obtained by this design is such that it will not unnecessarily subject life or property to risks higher than normal. Each unit will be nondestructively tested through radiography, liquid penetrant testing, and proof pressure testing to provide reasonable assurance that the mechanical integrity of each bottle is acceptable. In addition, each unit will incorporate a rupture disc safety device that will vent the Helium gas to atmosphere via a diffuser cap long before the internal pressure approaches the gas bottle's burst pressure.

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Summary

Carleton Technologies Incorporated respectfully submits this request, for the issuance of a special exemption, for your review and approval. We are confident you will concur that Carleton has demonstrated the ability to work in conjunction with the Department of Transportation to charge and ship a well engineered, inspected, and tested high pressure vessel..

For the reasons submitted, we feel approval of this exemption would be in the best interest of all parties concerned.

After reviewing this submittal, if you should have any questions, then please contact the undersigned as soon as reasonably possible. Thank you for your consideration.

Sincerely,

Matthew Petroski

Matt Petroski
Engineer
Military Systems
(716) 667-6489
(716) 662-0747 FAX

Attach

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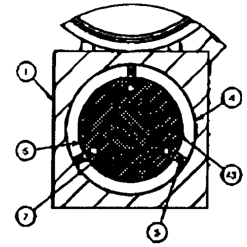
ATTACHMENT A

•Carleton Technologies Incorporated Drawing B43547

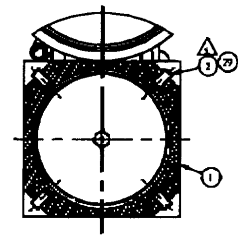
NOTES:

1. TORQUE PYROTECHNIC ACTUATOR (ITEM 36) TO 51-69 IN-LB.
2. TORQUE NUT (ITEM 8) TO
3. TORQUE NUT (ITEM 11) TO
4. TORQUE SEAT (ITEM 5) ONTO ROD (ITEMS 6 AND 7) TO
5. TORQUE LINER (ITEM 33) INTO RETAINER (ITEM 28) TO
6. TORQUE SET SCREW (ITEM 2) TO
7. TORQUE NEEDLE (ITEMS 34 AND 35) TO
8. TRACEABILITY REQUIRED BY SERNO. LASER ENGRAVE OR VIBRO ENGRAVE PART NUMBER AND SERNO AS SHOWN IN APPROXIMATE LOCATION USING .10±.05 HIGH LETTERING IAW MIL-STD-130.

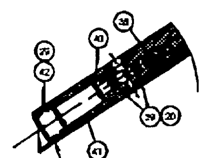
REV	ZONE	DESCRIPTION	DATE	APPROVED
-		RELEASED IAW ECN MG		DK



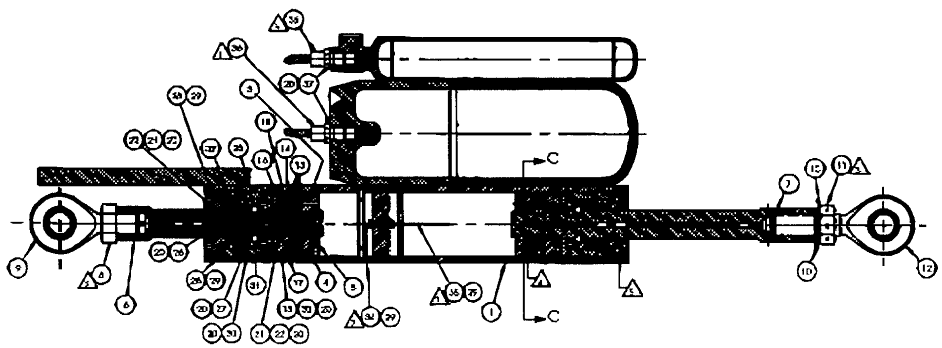
PARTIAL SECTION C-C SCALE 2/1



PARTIAL SECTION B-B SCALE 2/1



PARTIAL SECTION D-D SCALE 2/1



ITEM NO	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
44	1	X	X	
43	16	B43452-1	SPRING, RING	
42	2	AN565AC3/24H	SET SCREW	
41	2	B42850-1	PLUG	
40	2	B42853-1	SPOOL	
39	4	1000-0080-002	O-RING	
38	2	B43454-1	SPRING	
37	2	1000-0080-413	O-RING	
36	ALTN	3941519	CUTTER BURST DISK	
35	2	B40429-1	CUTTER BURST DISK	
35	1	B43884-1	NEEDLE	
34	1	B43349-1	NEEDLE	
33	2	B42857-1	LINER	
32	7	B42865-1	TRAYW SPRING	
31	2	B42556-1	RING PISTON	
30	4	1000-0080-067	O-RING	
29	AR	2055-0013 DSC	COMPOUND	
28	2	B42556-1	RETAINER	
27	2	1000-0080-022	O-RING	
26	2	1000-0080-219	O-RING	
25	20	B43588-1	BALL	
24	2	1000-0080-016	O-RING	
23	2	M8791/1-016	RING, BACKUP	
22	2	1000-0080-014	O-RING	
21	2	M8791/1-014	RING, BACK-UP	
20	AR	1058-0010-3	LUBRICANT	
19	1	X	X	
18	2	M8791/1-297	RING, BACK-UP	
17	2	B42583-1	PISTON	
16	2	B40458-1	SPRING, POPPET	
15	2	B40446-1	POPPET	
14	2	B40448-1	RING, RETAINER	
13	6	B42654-1	SPRING, BELLEVILLE	
12	1	M81935/1-06R	ROD END	
11	1	KA8809-5C	NUT	
10	1	NAS1193-6C	ADJUSTOR	
9	1	B43637-1	ROD END	
8	1	1030-0014-041	NUT	
7	1	B42583-2	ROD, SECOND STAGE	
6	1	B42582-1	ROD, FIRST STAGE	
5	2	B42588-1	SEAL SPRING	
4	6	B42561-1	RING, RETAINER	
3	6	2008-2012-020	PIN	
2	6	AN565BC4-4	SET SCREW	
1	1	B43523-1	RESERVOIR WELDMENT, ASSEMBLY	
		B43547-1	WING ACTUATOR ASSEMBLY	

PARTS LIST

UNLESS OTHERWISE SPECIFIED

INTERPRET DRAWING IAW MIL-STD-100. DIMENSIONS ARE IN INCHES. [illegible]

CONTRACT NO	
DRAWN L. DUMAN	00-12-2
CHECK D. MORIARTY	00-12-3
ENGINEERING D. MORIARTY	00-12-3
QUALITY ASSURANCE M. WAITE	00-12-3
APPROVED BY L. CAMPBELL	00-12-3

Carleton Technologies Inc

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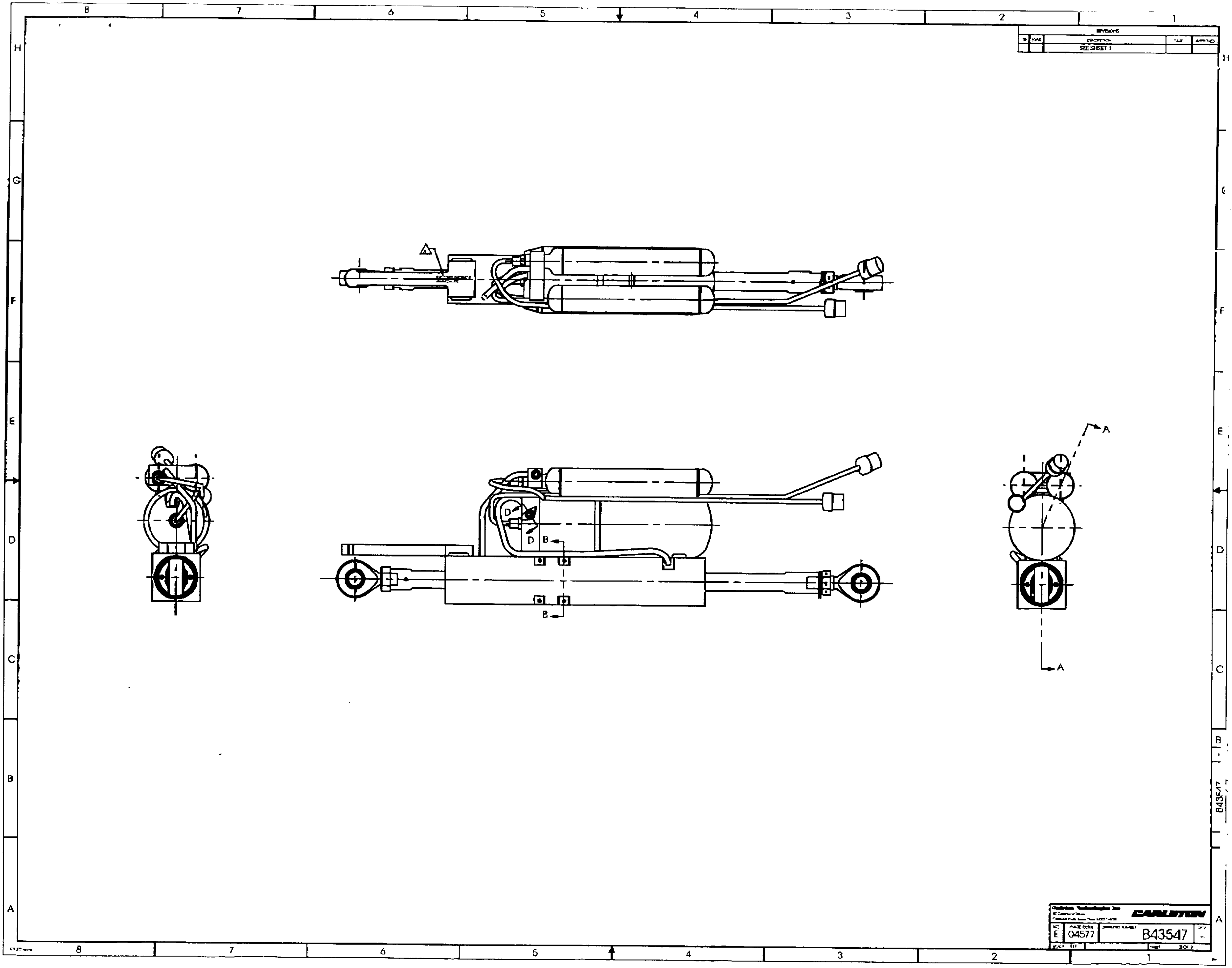
WING ACTUATOR ASSEMBLY

SIZE	CAGE CODE	DRAWING NUMBER	REV
E	04577	B43547	-

SCALE 1/1 SHEET 1 OF 1



SEE SHEET 1
A
A
B
B
D
D
E
04577
B43547

ATTACHMENT B

•Manufacturing, Inspection and Testing Flow Chart

Serialize Gas Bottle IAW MIL-STD-130

↓

Weld IAW MIL-STD-2219/Braze IAW MIL-B-7883

↓

Penetrant Inspect Weld IAW MIL-STD-6866
(Acceptance IAW MIL-STD-1907)

↓

Radiographic Inspect Weld IAW MIL-STD-453

↓

Burst Test One Gas Bottle Per Lot
(21,000 and 24,500 PSIG Burst Pressure min)

↓

Flattening Test on Sample Ring

↓

100% Proof Pressure Test (14,500 and 14,800 PSIG nominal)

↓

Fill Gas Bottles 9,200 ±200 and 10,700 ±200 PSIG

↓

Leak Check on Gas Bottle (1 x 10^{-5} scc/sec max)

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ATTACHMENT C

Stress Calculations for Cylinder and Spherical Sections of Gas Bottle:

(A) Cylinder 1 Larger Vessel

DOT Formula (178.65-7) $S = \dfrac{P\,(1.3\,D^2 + 0.4\,d^2)}{(D^2 - d^2)}$

(B) Sphere

DOT Formula (178.65-7) $S = \dfrac{P\,D}{4\,t}$

where:

			Cylinder	Sphere
S=	wall stress, psi			
P^{**}=	test pressure, psi		10,700psi/14,800psi/25,000psi	
D=	outside diameter, in.	MIN	2.329	2.055
d=	inside diameter, in.	MAX	1.995	---
t=	minimum wall thickness, in	MIN	---	0.172

NOTE **: The rated service pressure is 10,700 psig maximum at 73°F
The actual proof pressure is 14,800 ±200 psig.
Minimum DOT defined burst pressure is 25,000 psig.

(A) Cylinder

At the max service pressure (P = 10,700 psig), (T ≡ 73°F) $S_1 = 10{,}700\,\dfrac{(1.3\,(2.329)^2 + 0.4\,(1.995)^2)}{(2.329^2 - 1.995^2)}$

$S_1 =$ 64,038 psi

At the max test pressure (P = 15,000 psig), $S_2 = 15{,}000\,\dfrac{(1.3\,(2.329)^2 + 0.4\,(1.995)^2)}{(2.329^2 - 1.995^2)}$

$S_2 =$ 89,773 psi

At the min burst pressure (P = 25,000 psig), $S_3 = \dfrac{25{,}000\,(1.3\,(2.329)^2 + 0.4\,(1.995)^2)}{(2.329^2 - 1.995^2)}$

$S_3 =$ 149,621 psi

(B) Sphere

At the max service pressure (P = 10,700 psig), (T ≅ 73°F) $S_4 = \dfrac{10{,}700\,(2.055)}{4\,(.172)}$

$S_4 =$ 31,960 psi

At the max test pressure (P = 15,000 psig), $S_5 = \dfrac{15{,}000\,(2.055)}{4\,(.172)}$

$S_5 =$ 44,803 psi

At the min burst pressure (P = 25,000 psig), $S_6 = \dfrac{25{,}000\,(2.055)}{4\,(.172)}$

$S_6 =$ 74,762 psi

Each of the six (6) wall stress calculations performed result in wall stresses below the yield point of the material:

S_1 , S_2 , S_3 , S_4 , S_5 , S_6 < Yield Strength for PH13-8Mo H1025

F_y (Yield Strength) = 175 ksi
F_u (Ultimate Strength) = 185 ksi
(Ref.: MIL-HDBK-5E, PH13-8Mo Stainless Steel, Condition H1025)

The maximum wall stress occurs in the spherical portion of the gas bottle during the burst pressure testing:

$S_{max} = S_3 = 149{,}621$ psi

At the minimum burst pressure test point, the factor of safety of the bottle is:

$$F.S. = \frac{185{,}000 \text{ psi}}{149{,}621 \text{ psi}} = 1.23$$

Stress Calculations for Cylinder and Spherical Sections of Gas Bottle:

(A) Cylinder 2 Smaller Vessel

DOT Formula (178.65-7) $S = \dfrac{P\,(1.3\,D^2 + 0.4\,d^2)}{(D^2 - d^2)}$

(B) Sphere

DOT Formula (178.65-7) $S = \dfrac{P\,D}{4\,t}$

where:

			Cylinder	Sphere
S=	wall stress, psi			
P**=	test pressure, psi		9,400psi/14,700psi/21,000psi	
D=	outside diameter, in.	MIN	0.943	0.691
d=	inside diameter, in.	MAX	0.839	---
t=	minimum wall thickness, in	MIN	---	0.055

NOTE **: The rated service pressure is 9,400 psig maximum at 73°F
The actual proof pressure is 14,500 ±200 psig.
Minimum DOT defined burst pressure is 21,000 psig.

(B) Cylinder

At the max service pressure (P = 9,400 psig), ($T \cong 73°F$) $S_1 = \dfrac{9{,}400\,(1.3\,(0.943)^2 + 0.4\,(0.839)^2)}{(0.943^2 - 0.839^2)}$

$S_1 =$ 73,044 psi

At the max test pressure (P = 14,700 psig), $S_2 = \dfrac{14{,}700\,(1.3\,(0.943)^2 + 0.4\,(0.839)^2)}{(0.943^2 - 0.839^2)}$

$S_2 =$ 114,228 psi

At the min burst pressure (P = 21,000 psig), $S_3 = 21{,}000 \dfrac{(1.3\,(0.943)^2 + 0.4\,(0.839)^2)}{(0.943^2 - 0.839^2)}$

$S_3 =$ 163,118 psi

(B) Sphere

At the max service pressure (P = 9,400 psig), (T ≅ 73°F) $S_4 = \dfrac{9{,}400\,(0.691)}{4\,(.055)}$

$S_4 =$ 29,524 psi

At the max test pressure (P = 14,700 psig), $S_5 = \dfrac{14{,}700\,(0.691)}{4\,(.055)}$

$S_5 =$ 46,171 psi

At the min burst pressure (P = 21,000 psig), $S_6 = \dfrac{21{,}000\,(0.691)}{4\,(.055)}$

$S_6 =$ 65,959 psi

Each of the six (6) wall stress calculations performed result in wall stresses below the yield point of the material:

S_1, S_2, S_3, S_4, S_5, S_6 < Yield Strength for PH13-8Mo H1025

F_Y (Yield Strength) = 175 ksi
F_u (Ultimate Strength) = 185 ksi
(Ref.: MIL-HDBK-5E, PH13-8Mo Stainless Steel, Condition H1025)

The maximum wall stress occurs in the spherical portion of the gas bottle during the burst pressure testing:

$S_{max} = S_3 = 163{,}118$ psi

At the minimum burst pressure test point, the factor of safety of the bottle is:

$$F.S. = \frac{185{,}000 \text{ psi}}{163{,}118 \text{ psi}} = 1.13$$